High Impact Earthquake Risk in the Greater Cleveland, Ohio Area

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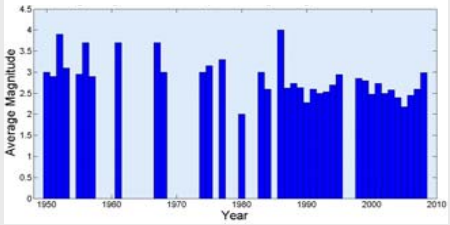
Objectives

- To make aware the risk for mid-continent earthquakes, especially in the greater Cleveland area of Ohio
- Analysis and assessment of earthquakes occurring in Ohio from 1900 to present day
- To compare the epicenters with relevant data such as magnetic concentrations, deep structures, and important man-made features such as hospitals, nuclear power plants and major roadways

Ohio Earthquakes: 1950-2008

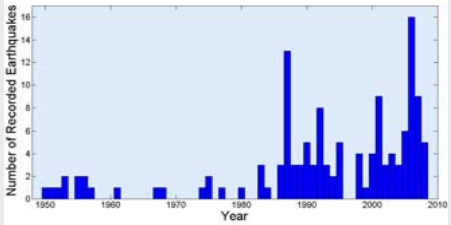
In the early 1900s Ohio earthquakes were poorly understood and recorded. Epicenters and their magnitudes were simply recorded and plotted based on reports of felt quakes by local people. This accounts for the inaccurate and misleading results prior to the 1980s. With 25 seismic stations scattered throughout Ohio we now have a much more accurate depiction of earthquakes originating in Ohio and their true magnitudes.

Average Magnitude of Earthquakes Originating in Ohio: 1950-2008



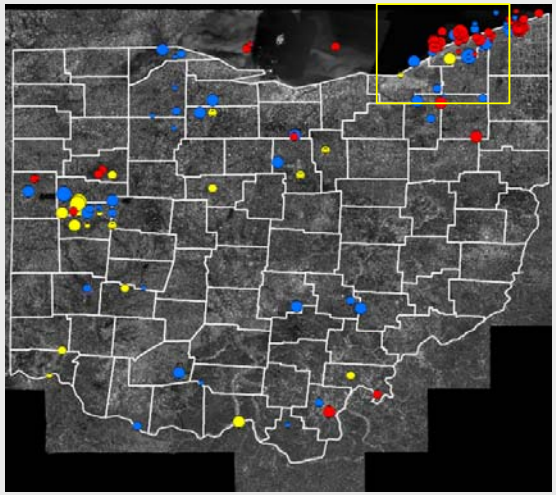
With more accurate monitoring of earthquakes we see that the average magnitude of Ohio based earthquakes is about 2.5. However, it is important to notice the peak magnitudes in 1986 which reached 5.0 and 4.5.

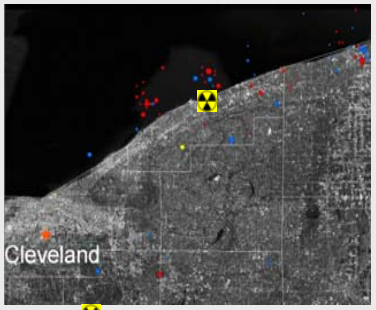
Earthquake Frequency of Epicenters Originating in Ohio: 1950-2008



With more accurate monitoring of earthquakes we see that the frequency of mid-continent earthquakes is much greater than predicted just 50 years ago.

Geologic Constraints on Ohio Earthquakes





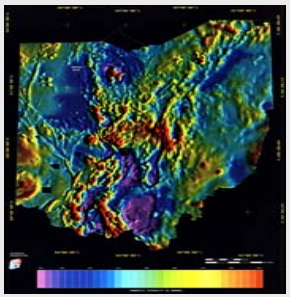
: Perry Nuclear Power Plant

Epicenters: Year and Magnitude

2000-2009 Magnitude	1950-1999 Magnitude	1900-1949 Magnitude
2.000000 - 2.300000	2.000000 - 2.500000	2.500000 - 3.000000
2.300001 - 2.800000	2.500001 - 3.100000	3.000001 - 3.700000
2.800001 - 3.400000	3.100001 - 3.900000	3.700001 - 4.400000
3.400001 - 4.500000	3.900001 - 5.000000	4.400001 - 5.400000

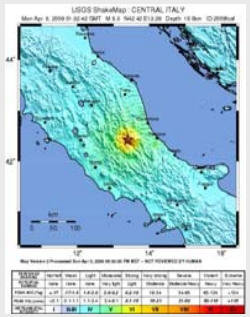
Map of Deep Structures in Ohio. This image shows deep faults and other structures throughout the state.

Map of Oil and Gas Pipelines in Ohio. This map shows the pipeline hubs and major fields at risk.



Map of Magnetic Intensities in Ohio. This image gives us a view past the soft sediment into the basement rock.

Destructive Earthquake in L'Aquila, Italy



http://media.nowpublic.net/images//4e/c/4ec1db5645022beb95566f22e114fc19.jpg

- April 6, 2009: a 6.3 magnitude earthquake occurs in L'Aquila, a small town in central Italy
- The earthquake was felt up to 90 miles away in Acona, Italy
- The earthquake was caused by normal faulting and E-W extensional tectonics
- Following the initial earthquake many more smaller magnitude aftershocks are felt in the next few months
- The earthquake and aftershocks left 300 dead and over 1,000 people injured
- Central Italy sits on a soft sedimentary accretionary wedge, much like Ohio's soft glacial till, making the potential for earthquake damage much greater

http://cricketdiane.files.wordpress.com/2009/04/l_aquila-destroyed_1380330i.jpg

Characterizing Seismic Risk

- Mmax is the magnitude M of the largest earthquake thought to be possible within a specified area
- Ohio sits on an SCR, Stable Continental Region, areas not typically known for seismic activity
- 20 LLNL experts predict the Ohio area to have an Mmax of 6.31 (IX on Mercalli)
- The Ohio Seismic region has a recurrence interval of about 200 years

Modified Mercalli Scale		Richter Magnitude Scale
I	Detected only by sensitive instruments	1.5
II	Felt by few persons at rest, especially on upper floors; delicately suspended objects may swing	2
III	Felt noticeably indoors, but not always recognized as earthquake; standing autos rock slightly, vibration like passing truck	2.5
IV	Felt indoors by many, outdoors by few, at night some may awaken; dishes, windows, doors disturbed; autos rock noticeably	3
V	Felt by most people; some breakage of dishes, windows, and plaster; disturbance of tall objects	3.5
VI	Felt by all, many frightened and run outdoors; falling plaster and chimneys, damage small	4
VII	Everybody runs outdoors; damage to buildings varies depending on quality of construction; noticed by drivers of autos	4.5
VIII	Panel walls thrown out of frames; fall of walls, monuments, chimneys; sand and mud ejected; drivers of autos disturbed	5 5.5
IX	Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked; underground pipes broken	6 6.5
X	Most masonry and frame structures destroyed; ground cracked, rails bent, landslides	7
XI	Few structures remain standing; bridges destroyed, fissures in ground, pipes broken, landslides, rails bent	7.5
XII	Damage total; waves seen on ground surface, lines of sight and level distorted, objects thrown up in air	8

Conclusions

- Ohio is predicted by LLNL experts to have a 6.31 magnitude earthquake
- Due to the loose glacial till, Ohio is at great risk for large areas of damage if a high magnitude earthquake were to happen
- Without changes in infrastructure the greater Cleveland area is at great risk for damage to over 40 hospitals, countless overpasses, oil and gas pipelines and Perry Nuclear Power Plant
- Perhaps the greatest risk is the lack of knowledge on the subject and the potential risk
- Future study into the poorly understood deep structures must be done to determine the true cause of the earthquakes

References

- Ohio Department of Natural Resources, ODNR < www.dnr.state.oh.us/ >
- The Ohio Seismic Network, OhioSeis < www.dnr.state.oh.us/OhioSeis/ >
- US Geologic Survey, USGS < www.usgs.gov/ >
- Wheeler, Russell L. "Methods of Mmax Estimation East of the Rocky Mountains." Us Department of the Interior (2009): 1-38.

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